LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT

ACCESSION FOR
NTIS GRA&I
DTIC TRAC
UNANNOUNCED
JUSTIFICATION

BY

DISTRIBUTION/

AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

19981223 000

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

HANDLE WITH CARE

DTIC FORM 70A JUN 90

DOCUMENT PROCESSING SHEET

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

LOAN DOCUMENT

NAVAL AIR DEVELOPMENT CENTER

WARMINSTER PA 18974

SYSTEMS DIRECTORATE

TECHNICAL MEMORANDUM 9-82 30 MARCH 1982

VP FUEL CONSERVATION QUARTERLY REPORT

(NOVEMBER 1981 - JANUARY 1982)

SUPPLEMENT

OPNAV 5216/144 (REV. 6-70)
S/N 0107-LF-778-6099

DEPARTMENT OF THE NAVY

Memorandum

2031
DATE: 14 JUN 1982

FROM: A. McCarty, 2031

TO: VP Report Distribution List

SUBJ: VP Fuel Conservation Quarterly Report Supplement; forwarding of

REF: (a) Report No. NADC 81319-20 "VP Fuel Conservation Report" of 31 Dec 1981

ENCL: (1) Technical Memorandum 9-82, "VP Fuel Conservation Quarterly Report" (November 1981 - January 1981) Supplement of 30 March 1982

1. Enclosure (1) is submitted for your information and retention.

2. Background material outlining the overall approach and data collection procedures is contained in reference (a). This enclosure (1) is a supplement to reference (a) and provides an update to the report with the next quarter of data. In keeping with the report, the supplement starts with section 3.0, Quarterly Data Summary.

3. Comments may be addressed to NAVAIRDEVCEN, Code 2031.

Albert M McCarty

A. McCARTY
AUTOVON 441-3099/3096

813

DEPARTMENT OF THE NAVY
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA. 18974

Systems Directorate

TECHNICAL MEMORANDUM 9-82 30 March 1982

VP FUEL CONSERVATION QUARTERLY REPORT (November 1981 - January 1982) Supplement

Prepared by: G. Katz
A. McCarty

Reviewed by: J. Nice

Approved by: M. Saitta
Chief, Sys Des Div

EXECUTIVE SUMMARY

Naval Air Development Center (NAVAIRDEVCEN) has been tasked by Naval Material Command (NAVMAT-08E) to examine changes in operational concepts, payloads, equipment and tactics that reduce fuel consumption. As part of this task NAVAIRDEVCEN has developed a data base to track fuel consumption for the VP community. The data base is used as a means of documenting fuel saving techniques. WING ELEVEN is currently participating in this endeavor.

This report contains detailed analysis on fuel consumption for partcipating VP squadrons (Patrol Squadrons Forty - Nine, Five and Twenty - Four) in the VP Fuel Conservation Study. The remaining squadrons of WING ELEVEN joined this effort after the reporting period of this report.

Background material outlining overall approach and data collection procedures is provided in NADC-81319-20, "VP Fuel Conservation Report (May - October 1981 Data)", 31 December 1981. Quarterly report supplements are provided to update this report. In keeping with the format of previous reports, the supplement starts with section 3.0, Quarterly Data Summary.

Conclusion:

On an average for all missions the squadrons are freighting fuel as follows (K lbs):

Month	Nov.	Dec.	Jan.	Average
Squadron A	2.6	4.6	3.9	3.7
B	6.9	5.7	8.8	7.1
C	-	-	5.4	5.4

TABLE OF CONTENTS

FIGURES

FIGURES (Continued)

TABLES

3.0 QUARTERLY DATA SUMMARY

3.1 FIRST QUARTER DATA SUMMARY

The first reporting period of the VP Fuel Conservation effort commenced in June 1981 with the data from June through August 1981. The squadron involved in the data collection and reporting during this period was PATRON FOUR NINE (VP-49) stationed at NAS Jacksonville, Florida. During the first quarter, VP-49 completed its pre-deployment preparation at NAS Jacksonville and deployed to Naval Air Facility (NAF) Sigonella, Sicily in mid July 1981. While deployed at NAF Sigonella, VP-49 operated flights from NAF Sigonella, Naples, Rome and Suda Bay. The results of the first quarter data are concontained in Reference 4.

3.2 SECOND QUARTER DATA SUMMARY

The second reporting period of the VP Fuel Conservation effort included data from September through October 1981. VP-49 continued to provide the data collection cards during the deployment to NAF Sigonella. PATRON FIVE (VP-5) also joined in the data collection starting in August. VP-5 is located at NAS Jacksonville, Florida and was just returning from a deployment prior to partaking in this effort. Therefore, the majority of the data cards received from VP-5 during the second quarter were from missions originating from NAS Jacksonville. However, some of the flights were from a detachment deployed to NAS Rota, Spain, the Azores and NAS Bermuda.

3.3 THIRD QUARTER DATA SUMMARY

The third reporting period of the VP Fuel Conservation effort included data from November 1981 through January 1982. VP-49 and VP-5 continued to provide the data collection cards during the reporting period. VP-49 was on deployment at NAF Sigonella during November and returned to NAS Jacksonville in the middle of December. VP-5 was at NAS Jacksonville the entire reporting period. PATRON TWO-FOUR (VP-24) joined the data collection effort in January 1982. VP-24 is currently operating from NAS Jacksonville.

The total number of data cards received and usable (denoted by being contained within paranthesis) by each squadron per month is depicted in Table 3-1.

SQUADRON	DATA CARDS RECEIVED (USABLE)			
	NOV	DEC	JAN	TOTAL
VP-49	118 (111)	72 (66)	60 (55)	250 (232)
VP-5	27 (25)	34 (31)	72 (72)	133 (128)
VP-24			44 (42)	44 (42)
	145 (136)	106 (97)	176 (169)	427 (402)

Table 3-1

Data Cards Received (Usable) Third Quarter

This table reveals a usable rate of 94% for those cards received which is considered excellent. It should be noted that in the analysis of the displays and the monthly summaries contained in Section 4 of this Technical Memorandum, that the sample sizes may be less than those contained in Table 3-1. This variation is due to the fact that a data card is considered usable if it contains specific data elements, not necessarily all data elements. Therefore elements on a data card may be missing and not available for the display computation and result in the inability to generate the individual display or analysis.

4.0 QUARTERLY DATA ANALYSIS

During this reporting period (November 1981 through January 1982) the major thrust of the analysis was directed towards excess fuel on board the aircraft, actual versus planned flight time, and fuel flow as a function of both mission phase and mission type. Three areas are considered. (1) Excess fueling was considered for analysis because of the direct relationship between aircraft weight and fuel flow (e.g., the heavier the aircraft the higher the fuel flow). (2) Planned vs. actual flight time was considered because of a potential correlation of aircraft fuel load and planned flight time. (3) Fuel flow was considered for analysis in order to determine the following factors: is fuel flow a function of mission type, and are aircrews adjusting and modifying procedures during various mission phases which result in a decrease in fuel usage.

4.1 EXCESS FUEL

There are several ways to look at excess fuel loads. An overview is shown in figure 4-1. This figure demonstrates a mean excess fuel at engine shutdown on a per flight per month per squadron basis. These values were obtained as follows (it should be noted that carrying extra fuel results in an increased aircraft gross weight and increased fuel consumption):

- Obtain the fuel remaining at engine start and at engine shutdown.
- Determine fuel used for each data collection card by subtracting the fuel remaining at engine shutdown from the fuel remaining at engine start.
- Add the specific on top fuel requirement for each of the bases to the fuel used and use this value as the "adjusted fuel load."
- To determine the excess fuel load, subtract the adjusted fuel load from the fuel remaining at engine start.

- Determine the mean value of the excess fuel loaded for the individual squadron per month and plot on figure 4-1.

Prior to review of the subsequent figures, it is important to note that flights which returned earlier than scheduled (due to aborts or cancellations) and flights which were extended were not included in this analysis, provided the data collection cards were annotated accordingly. Also, it is possible to obtain an approximation of the excess fuel being carried on the flights by multiplying the monthly excess fuel value by the sample size for that month.

A second way to examine fuel freighting is to sort the data into expected flight duration. Figure 4-2 is a summary of the overall excessive fuel freighted by each flight each squadron each month sorted into expected flight duration. The lower charts on figures 4-2 through 4-8 depict by month and by squadron the mean excessive fuel load for each half hour increment of time. The symbology used on figures 4-2 through 4-8 is as follows:

- A circle (o) indicates the mean fuel load at engine shutdown for the specified time increment of planned flight time.

- A triangle (Δ) indicates the minimum and maximum fuel loads at engine shutdown for the specified time increment of planned flight time.

- The rectangular shape at the far right hand side indicates the mean fuel load at engine shutdown and the 1 Sigma, standard deviation, of all flights about that mean.

- The dashed line (---) represents the on top fuel reserve requirement for the specified base location.

Review of these figures shows that aircraft have been carrying fuel loads in excess of the amount needed for the individual flights. The amount of fuel used, as depicted in figures 4-2 to 4-8, is actually higher than it would be if no excess fuel were carried. By carrying extra fuel, the aircraft gross weight is increased which results in an increased fuel consumption.

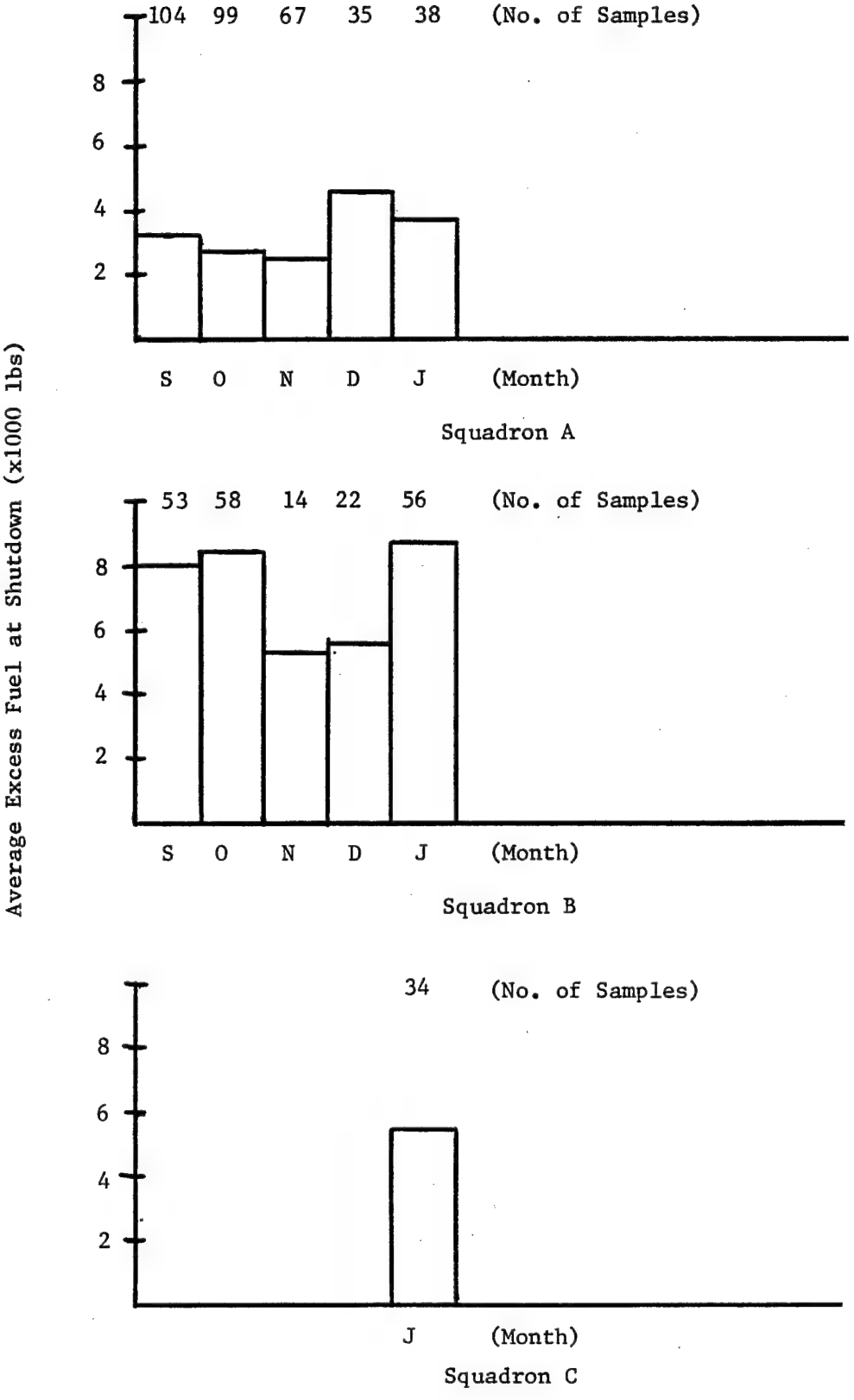


Figure 4-1 Average Excess Fuel At Shutdown (x1000 lbs) per Flight By Squadron

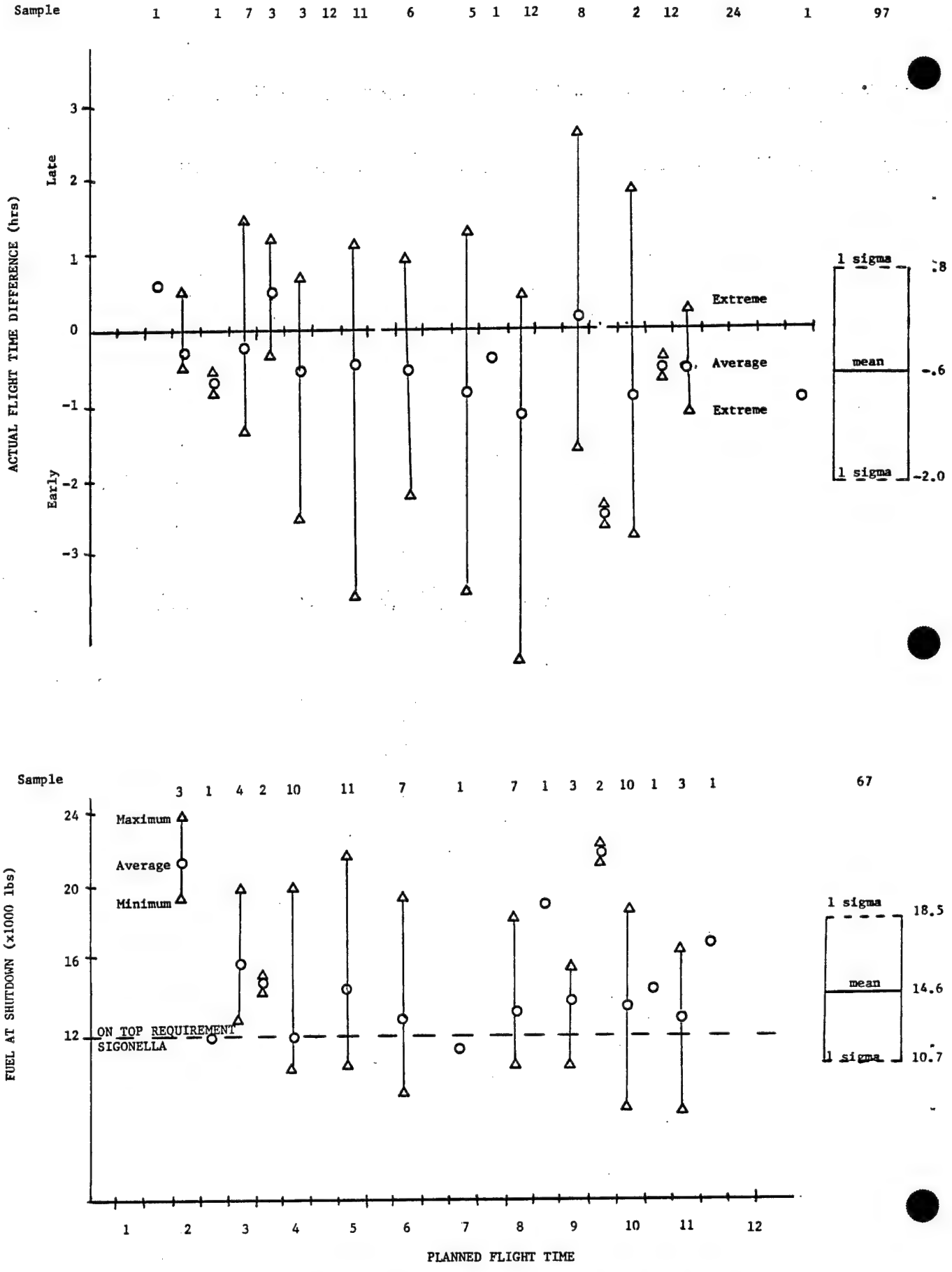


Figure 4-2 Squadron A November Fuel At Shutdown And Flight Time

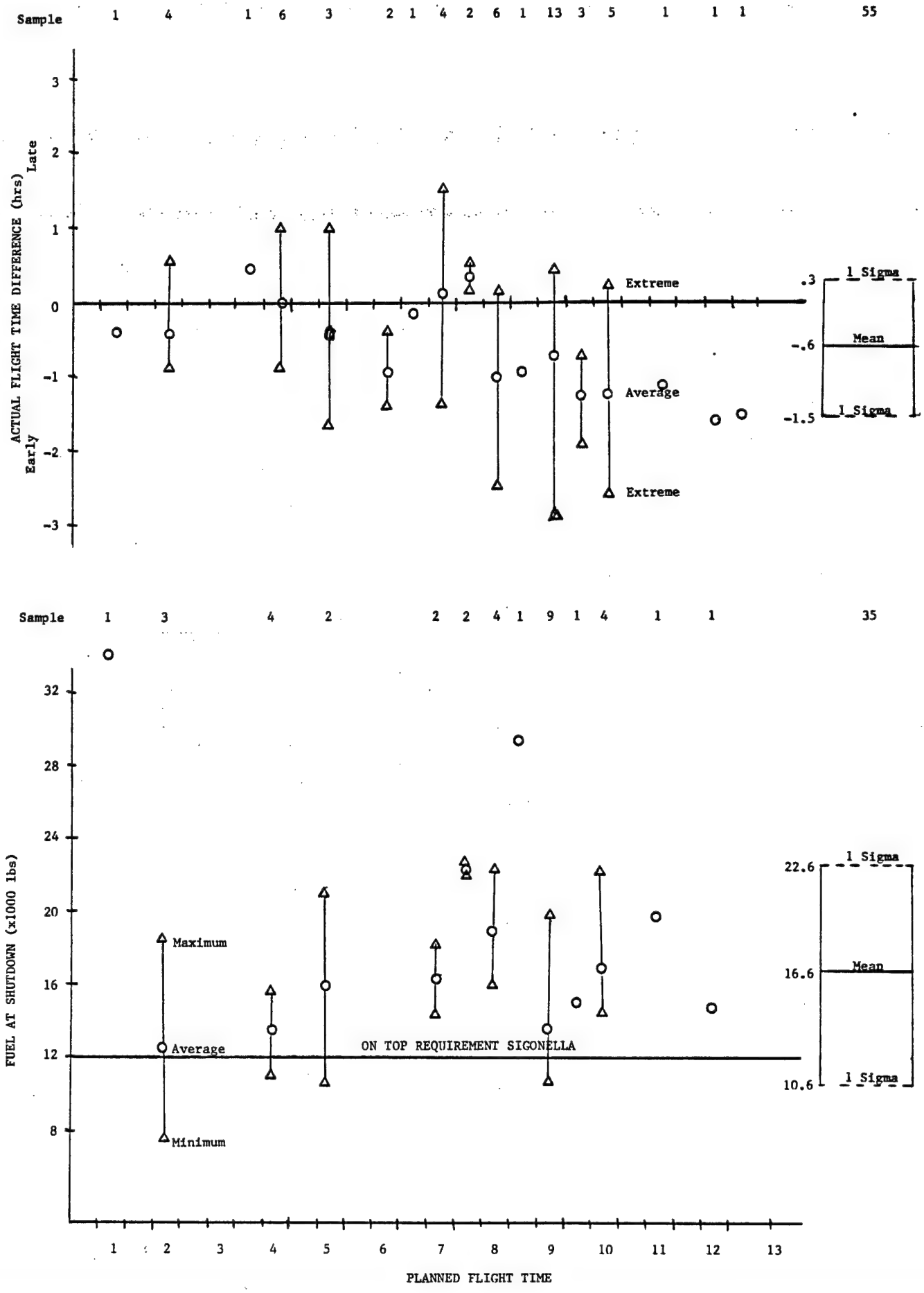


Figure 4-3 Squadron A December Fuel At Shutdown And Flight Time

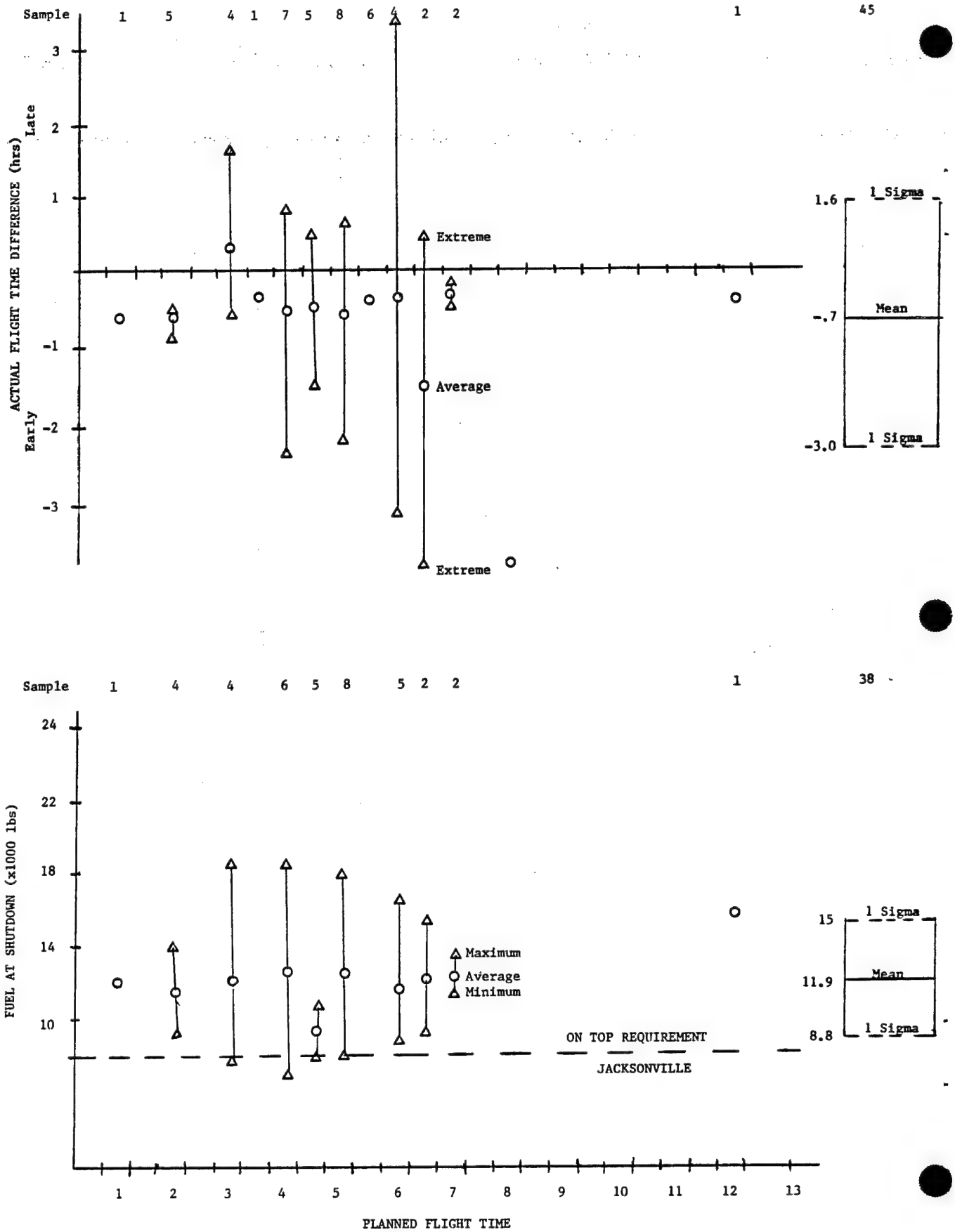


Figure 4-4 Squadron A January Fuel Shutdown And Flight Time

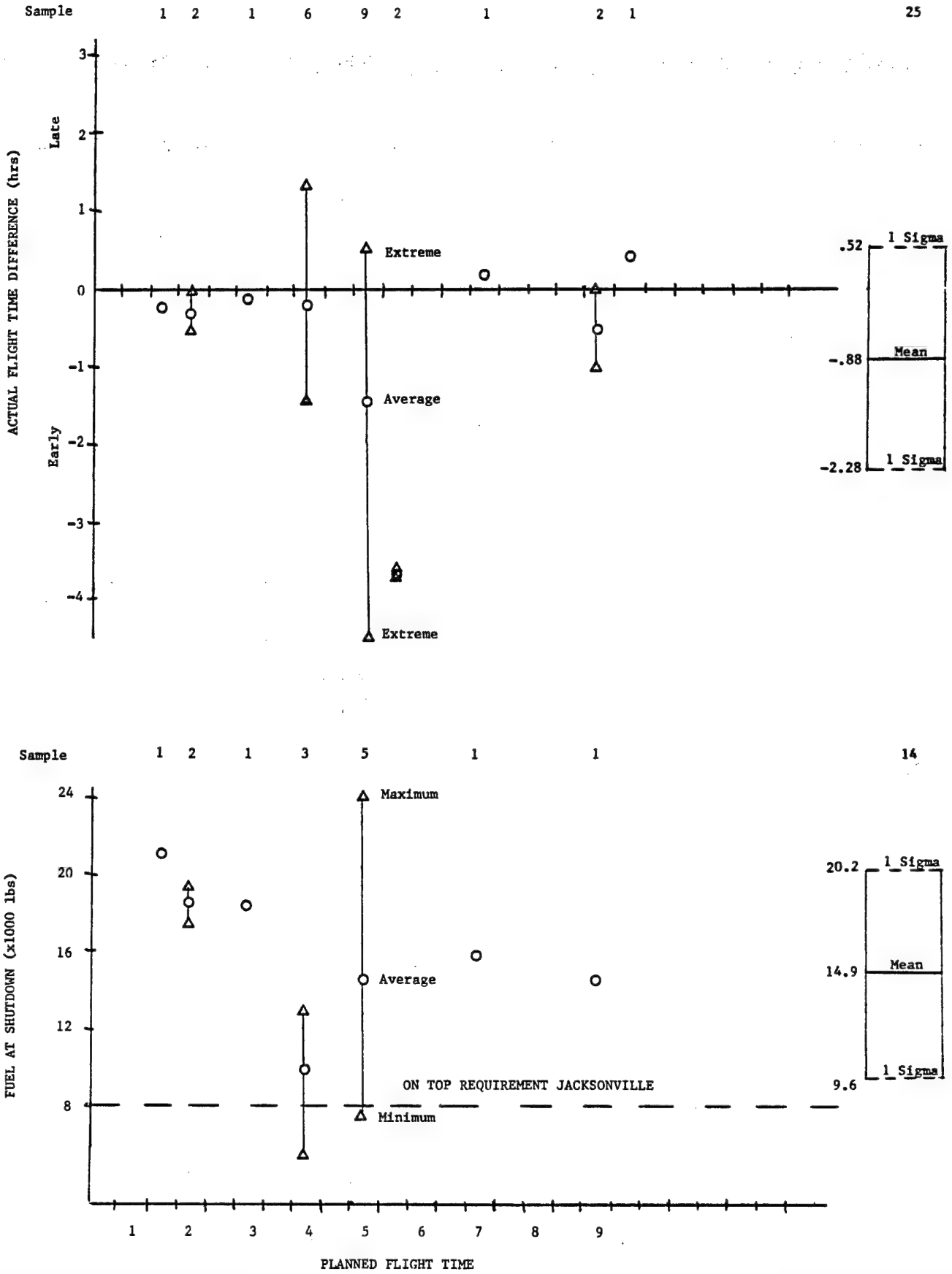


Figure 4-5 Squadron B November Fuel At Shutdown And Flight Time

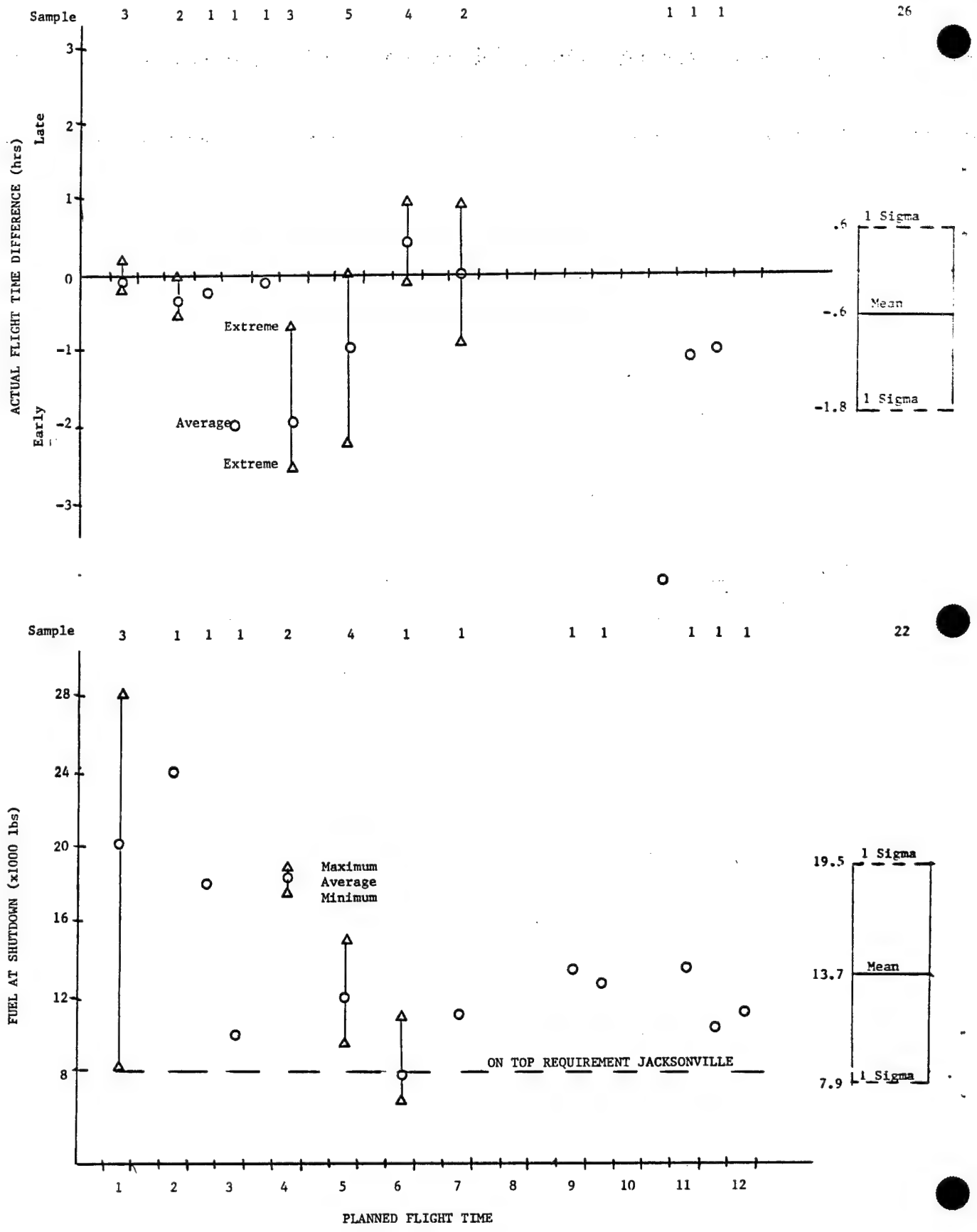


Figure 4-6 Squadron B December Fuel At Shutdown And Flight Time

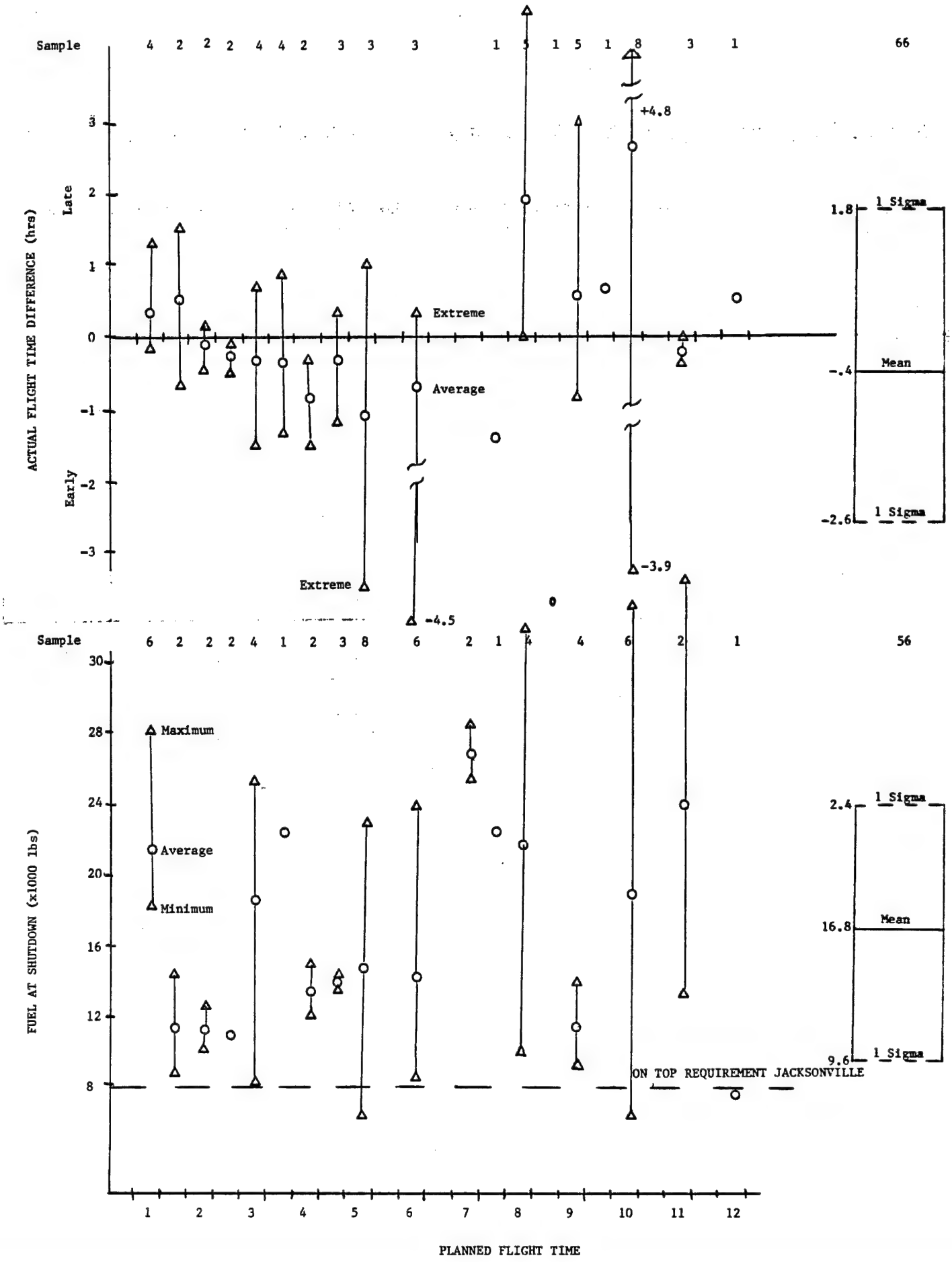


Figure 4-7 Squadron B January Fuel At Shutdown And Flight Time

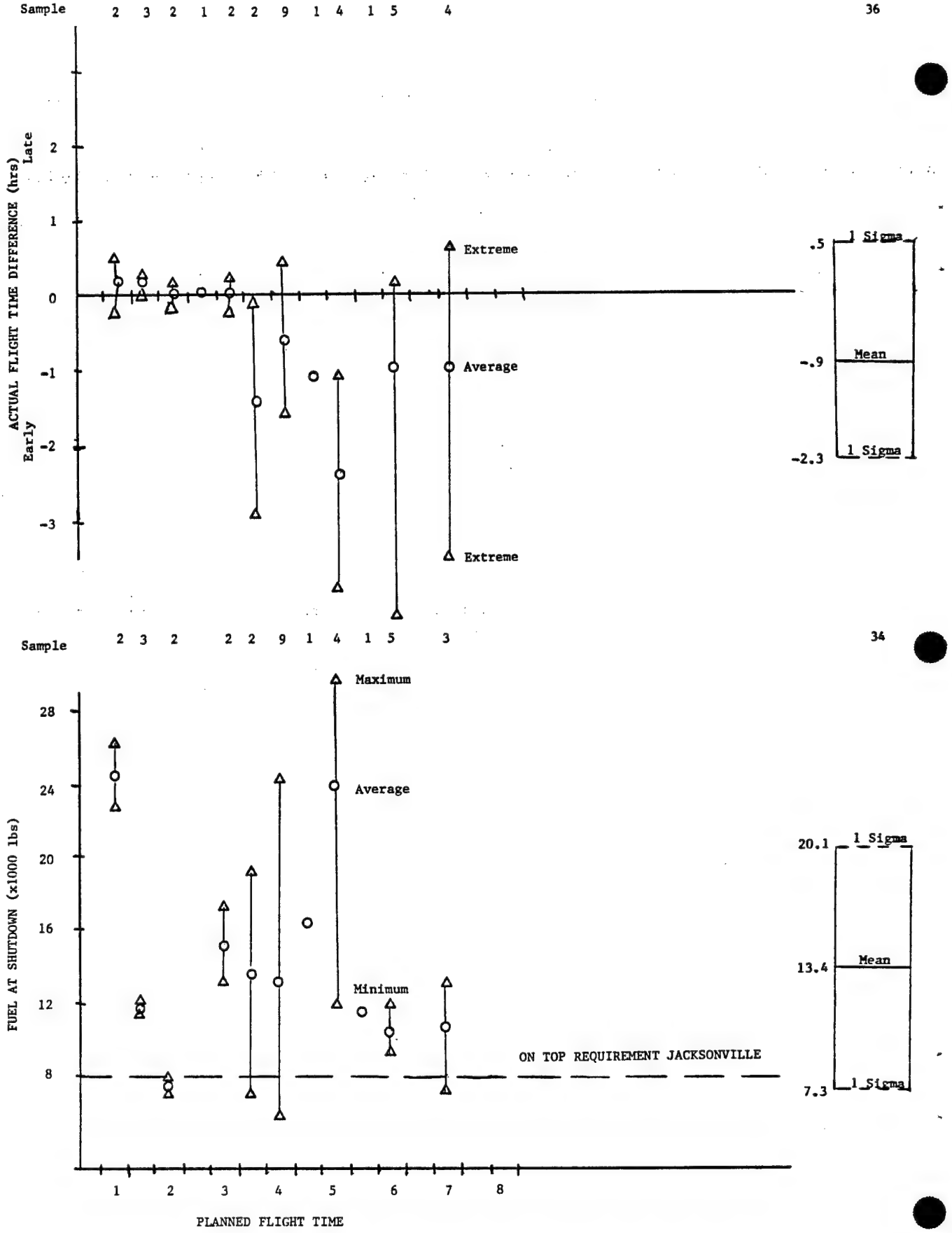


Figure 4-8 Squadron C January Fuel At Shutdown And Flight Time

4.2 PLANNED VS ACTUAL FLIGHT TIME

Analysis of planned vs actual flight time was performed by extracting the entry contained in the Expected Flight Hours data element (card 2 columns 25-27) and comparing that with the actual flight times. Actual flight time was determined as the difference between the take-off time entry (card 3 columns 1-4) and land time entry (card 6 columns 1-4). All flight data cards that recorded comments reflecting extended flights or aborted flights were eliminated from this analysis.

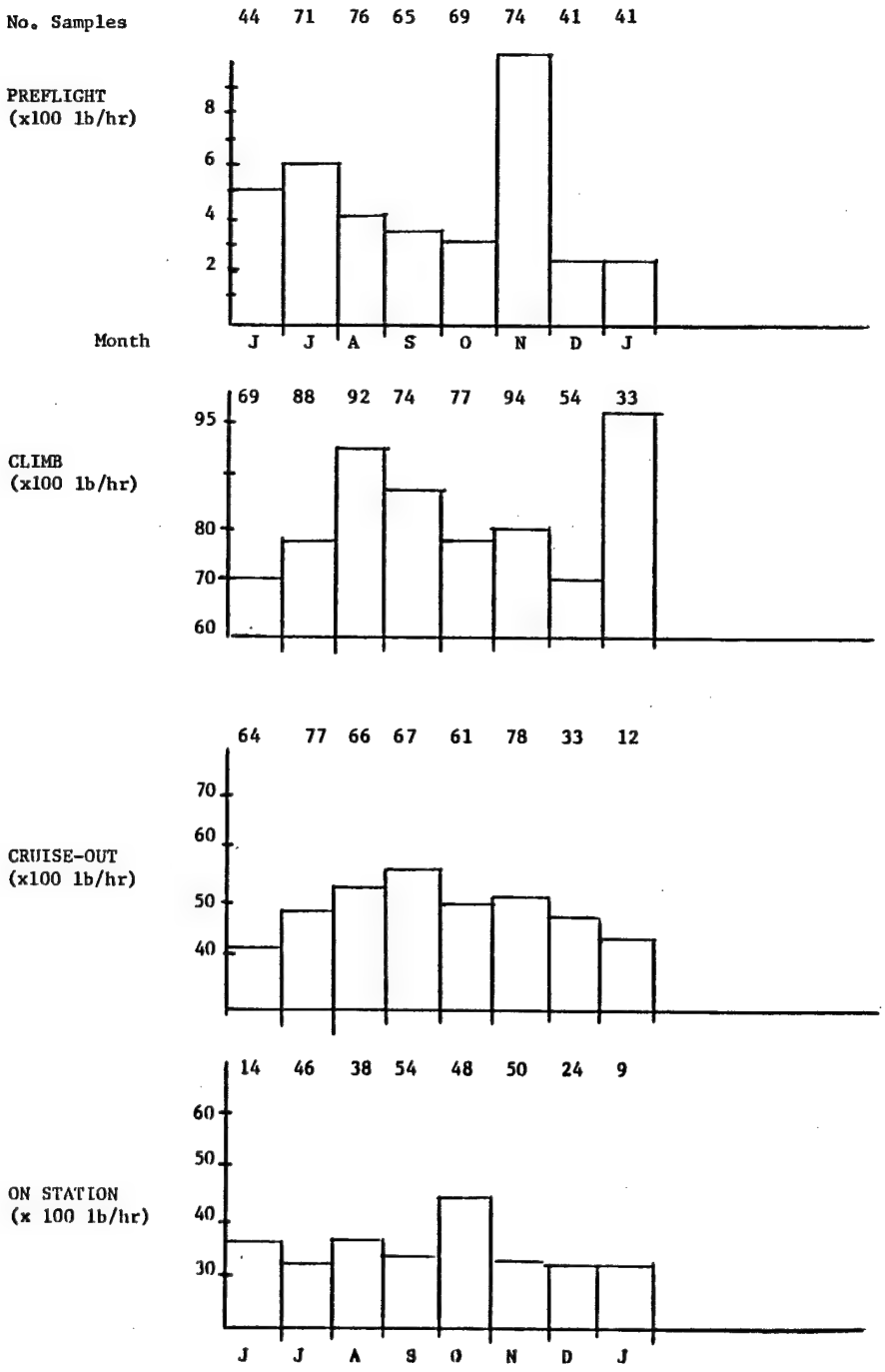
The upper charts on figures 4-2 through 4-8 depict the results of this analysis. For each one half hour increment of planned flight time, the mean actual flight time is plotted. Additionally, the largest varients for each increment have been displayed (dashed lines). The block at the extrement right of each graphic display contains the mean and 1 sigma, standard deviation, for all flights in that month. The sample size for each increment and total is displayed across the top of each display.

As can be observed in these charts on figures 4-2 through 4-8 all squadrons involved in the VP Fuel Conservation effort are flying less than the planned time on the average. It must be noted however, that a few flights have been returning 4-5 hours prior to scheduled time and these flights may be influencing the findings. Since no comments are included on the data cards, these flights must be used in the analysis.

4.3 FUEL FLOW

Fuel flow is being considered to determine variation within mission types and to observe trends on aircrew involvement to see where conservative measurements are being applied. Figures 4-9 through 4-10 depict the fuel flow by mission stage, mission type and month for each of the squadrons. Tables 4-1 through 4-4 summarize the results of the fuel flow analysis. All figures and tables are results of the OVERALL 01 display - Fuel Consumed by Stage of Flight (See Reference 4). Table 4-1 depicts the fuel flow by mission type for each squadron during this reporting period.

Examination of these tables have not been able to reveal any trends in fuel flow by mission type or mission phase. Tables 4-2 through 4-4 contain the fuel flow and sample size for each squadron by month, mission phase and mission type. Review of these tables shows that in many instances small sample sizes and improper data entries influences the results. Therefore establishment of trends becomes difficult. Those data points marked with astrisk (*) indicate suspect findings and should not be used in trend analysis. The current verify computer program is being modified to incorporate a system of checks which should eliminate bad data points.



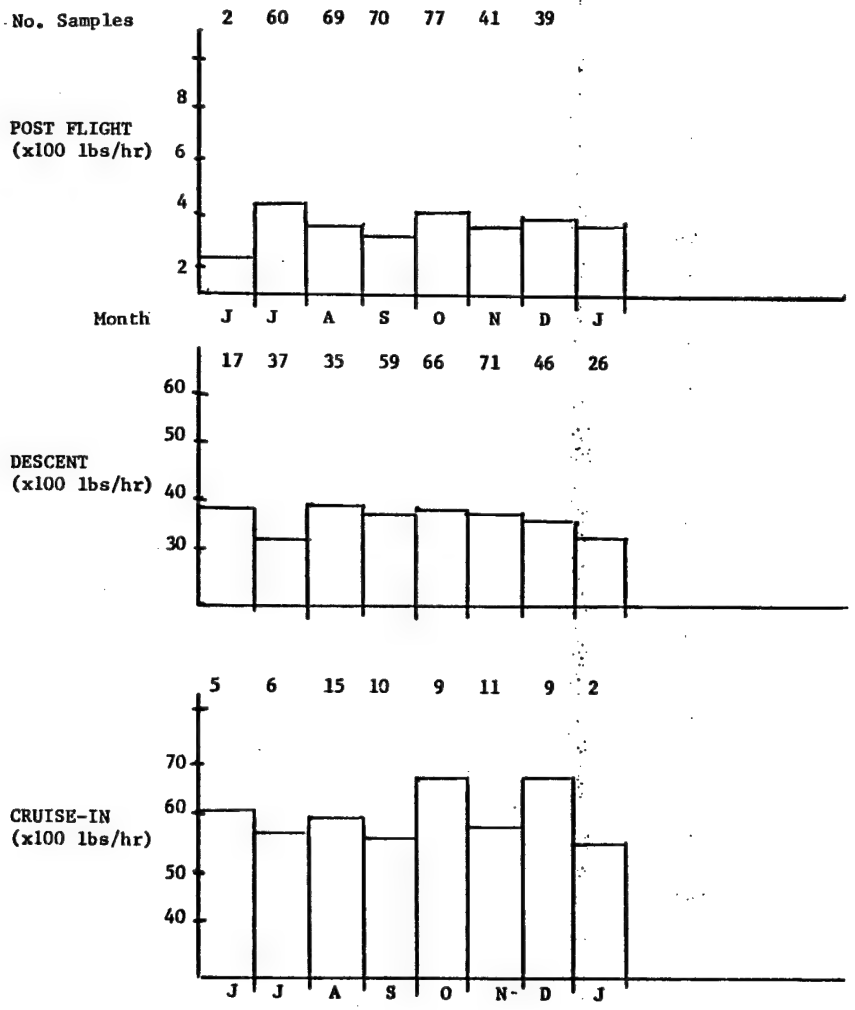
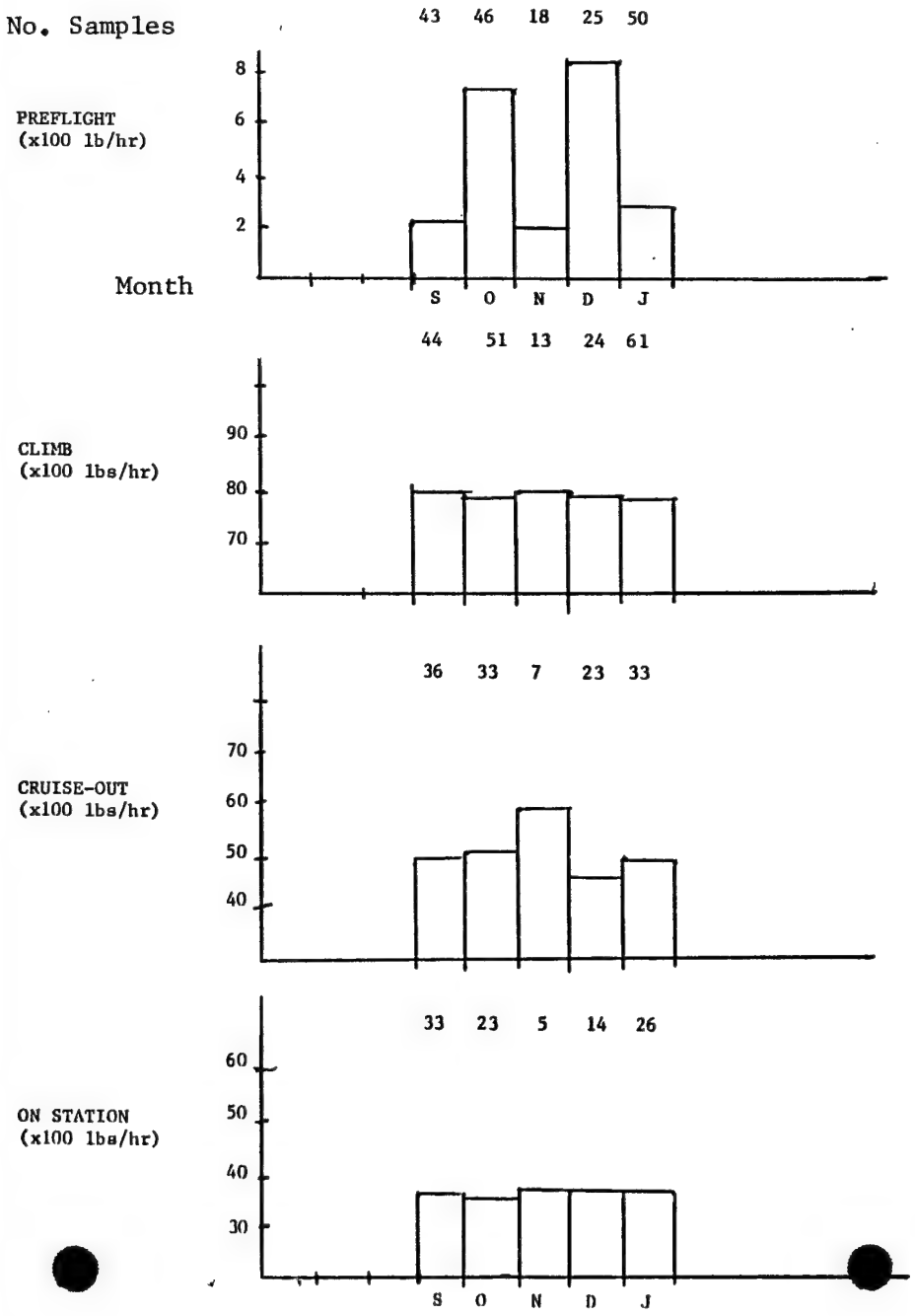


Figure 4-9 Squadron A Fuel Flow By Mission Phase All Missions



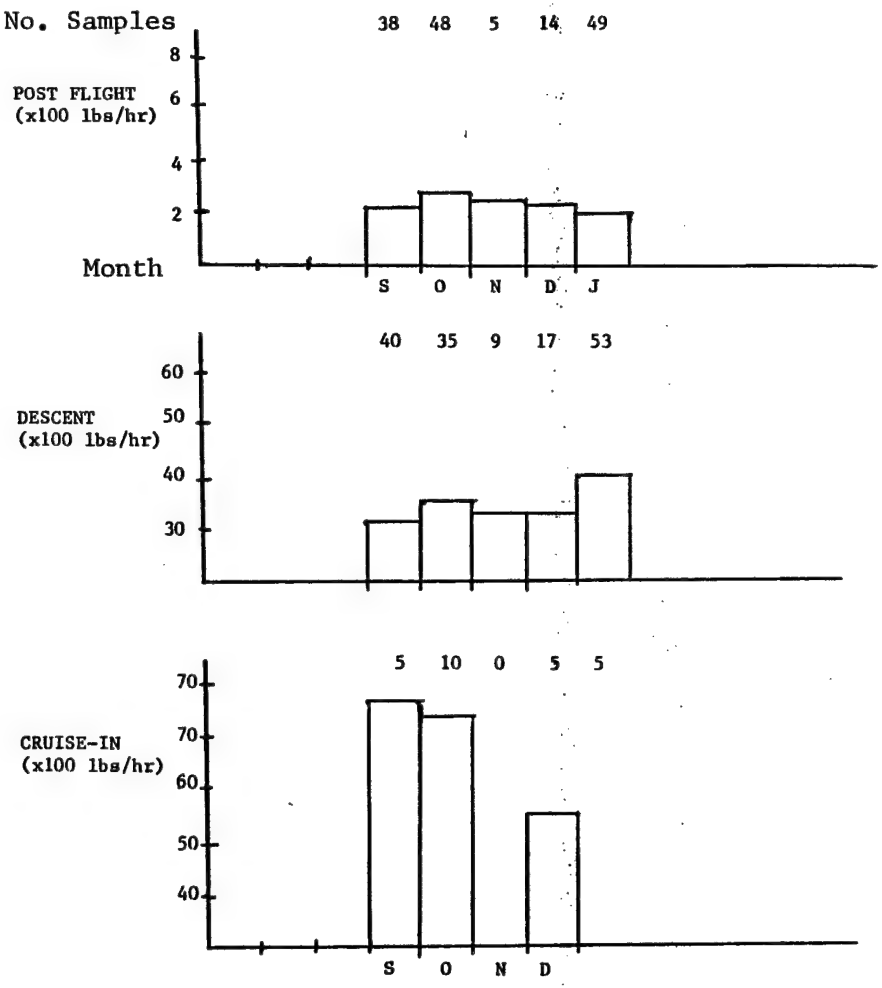


Figure 4-10 Squadron B Fuel Flow By Mission Phase All Missions

SQUADRON	MISSION TYPE	NOV	DEC	JAN
A	ASW	4054	4035	4164
	SS	4271	4226	4011
	DD	-	-	-
	FAM	3720	3493	4375
	XCTY	3404	3830	3502
	OTHER	3293	4294	4194
B	ASW	3326	3794	4065
	SS	-	3771	4345
	DD	-	3092	3703
	FAM	3908	4263	4316
	XCTY	4206	4033	3700
	OTHER	4322	6880*	4231
C	ASW			4194
	SS			4493
	DD			-
	FAM			4211
	XCTY			4435
	OTHER			4127

NOTE: Fuel Flow (lbs/Hr)

Table 4-1 Overall Fuel Flow By Mission Type

FUEL FLOW	MISSION TYPE	NOV	DEC	JAN
PRE-FLIGHT	ALL	326/81	242/48	228/41
	ASW	375/31	205/19	255/4
	SS	231/7	240/1	180/2
	DS	-	-	-
	FAM	240/10	390/2	207/18
	XCTY	344/22	252/20	282/13
	OTHER	289/11	280/6	150/4
POST-FLIGHT	ALL	2561/77	2719/41	2763/39
	ASW	2345/26	1890/12	2600/3
	SS	1887/9	1200/1	1230/2
	DS	-	-	-
	FAM	2989/11	2340/2	2548/15
	XCTY	2812/22	3223/21	3270/14
	OTHER	2727/9	3048/5	2700/5
CLIMB	ALL	8281/94	7038/54 *	10756/33 *
	ASW	7337/35	7083/21	9000/5
	SS	8100/9	14220/1 *	14550/2 *
	DS	-	-	-
	FAM	9409/11	5850/2	8430/8
	XCTY	9434/29	6487/25	9304/14
	OTHER	2727/9	3048/5 *	2700/5 *
DESCENT	ALL	3725/71	3660/46	3258/26
	ASW	3900/32	3399/20	4020/5
	SS	3866/7	7740/1	3300/2
	DS	-	-	-
	FAM	4200/6	2760/1	3560/3
	XCTY	3229/17	3856/19	3235/13
	OTHER	3613/9	3324/5	1760/3

NOTE: Fuel Flow (lbs/Hr)/No. of Samples

NOTE: * indicates suspect data

Table 4-2 Fuel Flow By Mission Phase and Mission Type - Squadron A

FUEL FLOW	MISSION TYPE	NOV	DEC	JAN
CRUISE-OUT	ALL	5102/78	4829/33	4465/12 *
	ASW	5268/36	4766/21	4060/3
	SS	5198/8	5040/1	14550/2 *
	DS	-	-	-
	FAM	4234/7	-	3900/3
	XCTY	4793/18	4713/9	5025/4
	OTHER	5640/9	5910/2	5700/1
CRUISE-IN	ALL	5809/11	6827/9	5550/2
	ASW	5786/7	6827/9	5100/1
	SS	5460/1	-	-
	DS	-	-	-
	FAM	6180/1	-	-
	XCTY	6960/1	-	-
	OTHER	4800/1	-	6000/1
ON STATION	ALL	3894/50	3882/24	3747/9
	ASW	3763/32	3873/22	3540/4
	SS	4286/7	3360/1	4020/2
	DS	-	-	-
	FAM	3880/3	-	-
	XCTY	3980/3	-	3990/2
	OTHER	4140/5	4620/1	3540/1

NOTE: Fuel Flow (lbs/Hr) /No. of Samples

NOTE: * indicates suspect data

Table 4-2 Fuel Flow By Mission Phase and Mission Type - Squadron A (continued)

FUEL FLOW	MISSION TYPE	NOV	DEC	JAN
PRE-FLIGHT	ALL	180/104	838/25 *	277/50
	ASW	200/2	300/8	251/16
	SS	-	400/1	160/3
	DS	-	100/1	180/1
	FAM	200/11	300/4	230/6
	XCTY	300/3	2600/6 *	364/14
	OTHER	100/2	300/5	270/10
POST-FLIGHT	ALL	2227/51	2117/21	1965/49
	ASW	1500/3	1700/6	2036/16
	SS	-	1800/1	4230/2
	DS	-	-	0/0
	FAM	2400/8	2700/4	1824/5
	XCTY	1900/4	1700/6	1627/17
	OTHER	2400/2	2900/4	2053/9
CLIMB	ALL	7837/13	7782/24 *	7601/61 *
	ASW	7900/5	9100/8	7242/17
	SS	-	-	9960/3
	DS	-	7400/2	6300/1
	FAM	9700/3	110 000/3 *	11 920/6 *
	XCTY	6700/5	5400/7	6493/23
	OTHER	-	7100/4	7593/11
DESCENT	ALL	3293/9	3307/17 *	4150/53
	ASW	4000/4	3200/8	5857/18
	SS	-	6000/1	3150/2
	DS	-	400/1 *	4200/1
	FAM	1600/1	1700/1	2460/2
	XCTY	3000/4	6800/2	3197/21
	OTHER	-	2300/2	3553/9

NOTE: Fuel Flow (lbs/Hr) / No. of Samples

NOTE: * indicates suspect data

Table 4-3 Fuel Flow By Mission Phase and Mission Type - Squadron B

FUEL FLOW	MISSION TYPE	NOV	DEC	JAN
CRUISE-OUT	ALL	5983/7 *	4505/23	4808/33
	ASW	4400/4	4000/8	5503/14
	SS	-	3200/1	5140/3
	DS	-	4200/2	2520/1
	FAM	101 000/3 *	5900/3	4380/2
	XCTY	4100/1	4600/6	4200/4
	OTHER	-	5000/3	4220/9
CRUISE-IN	ALL	0/0	5640/5	28 080/5 *
	ASW	-	3200/8	32400/3 *
	SS	-	-	0/0
	DS	-	-	0/0
	FAM	-	-	0/0
	XCTY	-	-	0/0
	OTHER	-	5400/2	21 600/2 *
ON STATION	ALL	4104/5	4089/14	4071/26
	ASW	4400/4	4300/8	3840/13
	SS	-	3800/1	4380/3
	DS	-	4000/1	4080/1
	FAM	3109/1	3300/2	4320/1
	XCTY	-	-	3900/2
	OTHER	-	4300/2	4430/6

NOTE: Fuel flow (lbs/hr)/No. of Samples

NOTE: *indicates suspect data

Table 4-3 Fuel Flow By Mission Phase and Mission Type - Squadron B (Continued)

FUEL FLOW	MISSION TYPE	NOV	DEC	JAN
PRE-FLIGHT	ALL			402/23
	ASW			140/3
	SS			180/2
	DS			-
	FAM			200/3
	XCTY			644/11
	OTHER			195/4
POST-FLIGHT	ALL			2229/27
	ASW			1980/3
	SS			2520/1
	DS			-
	FAM			2124/5
	XCTY			2336/15
	OTHER			1786/26
CLIMB	ALL			7258/37 *
	ASW			7200/4
	SS			7140/1
	DS			-
	FAM			5160/4
	XCTY			6433/23
	OTHER			12804/5 *
DESCENT	ALL			3815/29
	ASW			3675/4
	SS			6000/1
	DS			-
	FAM			4120/3
	XCTY			3445/17
	OTHER			4755/4

NOTE: Fuel Flow (lbs/Hr)/No. of Samples

NOTE: * indicates suspect data

Table 4-4 Fuel Flow By Misson Phase and Mission Type - Squadron C

FUEL FLOW	MISSION TYPE	NOV	DEC	JAN
CRUISE-OUT	ALL			4041/14
	ASW			4200/3
	SS			3060/1
	DS			-
	FAM			3600/1
	XCTY			4050/4
	OTHER			4224/5
CRUISE-IN	ALL			0/0
	ASW			0/0
	SS			0/0
	DS			-
	FAM			0/0
	XCTY			0/0
	OTHER			0/0
ON STATION	ALL			4631/11
	ASW			3930/4
	SS			3060/1
	DS			-
	FAM			4020/1
	XCTY			0/0
	OTHER			3672/5

NOTE: Fuel Flow (lbs/Hr)/No. of Samples

NOTE: *indicates suspect data

Table 4-4 Fuel Flow By Mission Phase and Mission Type - Squadron C (Continued)

5.0 CONCLUSIONS

1. The cooperation and assistance of personnel at COMPATWING-11, VP-49, VP-5 and VP-24 continues to be exceptional. This is exemplified by the 94% usable data cards which have been received.

2. According to the Fuel at Shutdown figures 4-1 through 4-8, the squadrons are carrying excessive fuel for the planned flight hours as shown below. This equates to carrying unnecessary weight which results in the consumption of additional fuel.

Squadron \ Month	NOV	DEC	JAN	QUARTER AVERAGE
A	2600	4600	3900	3700
B	6900	5700	8800	7100
C	--	--	5400	5400

Average Excessive Freighted Fuel (lbs)

3. The greater portion of flights which carry excess fuel appears to be those flights of 5 hour planned flight time or less. This may be a result of excessive ramp load requirements at the individual bases and should be investigated in detail.

4. The Fuel Flow By Mission Phase All Missions (Figures 4-9 and 4-10) indicate the establishment of a trend which is decreasing. This trend demonstrates the flight crews awareness of fuel conservation techniques.

5. The Fuel Flow By Mission Phase and Mission Type tables (Tables 4-2 through 4-4) indicate that fuel flows vary by mission type. However, no consistent patterns or trends have been noted in the analysis which would enable a determination of the higher fuel consumption mission type by mission phase. This area will continue to be investigated in subsequent technical memorandums.

6. The cruise-in fuel flow continues to be higher than the cruise-out fuel flow. The lighter aircraft during cruise-in should result in a lower fuel flow. Although this area has not been analyzed in depth, areas to be investigated will include altitudes and airspeeds.

7. A review of the data cards received at NAVAIRDEVCEN reveals that on numerous flights (primarily cross countries), flight crews have maintained only one data card for all legs of flight. This has a tendency of affecting the analysis, especially fuel flows and flight times, and consideration of multiple data cards for multiple stop flights should be made.

8. Actual flight times-expected flight time mean as shown in figures 4-2 through 4-8 might be reduced if flights which varied by more than 1 hour were not considered. This would assure that a flight difference more than one hour is unuseable, but, since the analyst cannot determine the reasons for these excessive variations unless comments are included (such as cancellations and aborts), all flights are considered in the analysis.

6.0 RECOMMENDATIONS

1. COMPATWING-11, VP-49, VP-5 and VP-24 should be officially commended for their excellent cooperation during the VP Fuel Conservation effort.

2. Squadron Operations Departments, Maintenance Control and flight crews should re-evaluate fuel loads being carried as a function of expected flight duration within established requirements when fueling the aircraft. This should result in a reduction of the amount of fuel at landing such that it approaches the on-top requirement for the specific base.

3. Investigation of ramp load requirements at each base should be conducted to determine the operational impact of reducing the ramp loads in an effort to reduce excess fuel on short duration flights.

4. All cruise-out and cruise-in should be made at maximum range operating capabilities of the aircraft within operational commitments.

5. When filling out the data cards, especially on cross country flights with multiple stops, the flight crew is requested to complete a separate data card for each flight leg. This should be standard procedure whenever the aircraft refuels or is on the ground in excess of 30 minutes.

6. Whenever the actual flight time varies from the expected flight time by more than 1 hour, the flight crew is requested to specify the reason in the comments. The reason could be generalized to state "extended for 2 hours, abort, cancel, etc.".

REFERENCES

1. NAVAIRDEVCEN Rough Draft "VP Fuel Conservation Experiment Design and Analysis Plan", 15 April 1981.

2. NAVAIRDEVCEN/UNIVAC Report "SFM Data Utility/Management Program Description and User Guide", 15 September 1981 (to be published)

3. NAVAIRDEVCEN Report, "VP Fuel Conservation Quarterly Report (June - August 1981), D. Bellins, G. Katz, A. McCarty.

4. NAVAIRDEVCEN Report No. NADC-81319-20", VP Fuel Conservation Report (May-October 1981 Data), D. Bellis, G. Katz, A. McCarty, 31 December 1981.